Data Assimilation with Regional Lagrangian Models

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LONG-TERM GOALS

The long term goal is regional modeling and data assimilation, allowing us to test models, and get good estimates of the state of the ocean. These 'inverse' estimates use the data to overcome errors in initial conditions, in boundary conditions, and in dynamical parameterizations.

OBJECTIVES

The objective is to assimilate float or drifter data from both coastal waters and the deep ocean, over a period of at least three months, into a stratified primitive equation model.

APPROACH

Regional primitive equation models are ill-posed, if the domain is Eulerian. However, they are well-posed if the domain is Lagrangian (Bennett and Chua,1999). It is therefore possible to find efficient solutions of the inverse or data assimilation problem in Lagrangian domains, using the methods developed here in the last decade. My postdoctoral fellow Jodi Mead had committed the last 24 months to computing solutions of the inverse problem in a Lagrangian domain together with synthetic data. She will continue work on this project for at least the next 12 months.

WORK COMPLETED

Beta-plane tests of the viscous shallow water equations in Lagrangian coordinates have included integrations of uniformly rotating flow with open boundaries, and spatially periodic integrations on the time and space scales of North Atlantic mesoscale variability.

The results of the integrations are in close agreement (3%) with those of Eulerian integrations of an otherwise identical model, for 100 days or more.

For variational assimilation of real N. Atlantic float and hydrography data, the tangent linear form, and adjoint , of the viscious Lagrangian model has been derived in spherical polar coordinates . These operators are being implemented iteratively in a fully nonlinear assimilation scheme.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Data Assimilation with Regional Lagrangian Models**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **College of Oceanic & Atmospheric Sciences,,Oregon State University,104 Ocean Admin Bldg,,Corvallis,OR,97331**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

With help from A Macdonald of WHOI, we have used N. Atlantic hydrograhic data from "HYDROBASE" to compute Montgomery potentials on isopycnal surfaces. These will provide 'first guess' or 'background' boundary conditions and initial conditions for assimilations of real float tracks and depths.

A presentation of this work will be given at the meeting `Lagrangian Analysis and Predictability of Coastal and Ocean Dynamics", October 2-6, 2000 in Ischia, Italy.

A rational derivation of open boundary conditions has been made for diffusive hydrostatic and nonhydrostatic dynamics, as no derivation could be found in the published literature.

RESULTS

With a uniformly rotating flow, the viscous Lagrangian model accurately describes a moving domain for time periods of at least 160 days. This is a nested experiment, and the values at the open boundaries are interpolated from a known Eulerian field . Such interpolation anticipates the use of real hydrographic data provided on Eulerian grids.

The integrations with time and space scales of North Atlantic mesoscale variability yielded a highly nonlinear flow regime , with complex float trajectories. Real float data are of comparable complexity. Successful assimilation of simulated data of this type should lead to successful assimilation of the real data.

IMPACT/APPLICATIONS

There is little published material on the Lagrangian form of the equations of fluid dynamics, or suitable numerics, most likely because the Lagrangian viewpoint is uncommon. Semi-Lagrangian numerics are common for efficient time integrations in numerical weather prediction, but they involve interpolation to a fixed grid, which is not desirable for assimilation of float or drifter data. Semi-Lagrangian methods are awkward in this context, but may be computationally competitive. The Lagrangian viewpoint will give new insights into ocean circulation, both as a forward model and as a basis for assimilating data.

TRANSITIONS

Not applicable

RELATED PROJECTS

We are implementing semi-Lagrangian methods to determine if they conserve the well-posedness of the open boundaries. We are also exploring Lattice Boltzmann methods for well-posed regional modeling and variational assimilation in Eulerian domains.

REFERENCES

A. F. Bennett and B. S. Chua, 1999: Open boundary conditions for Lagrangian geophysical fluid dynamics, Journal of Computational Physics, 153, 418-436.

PUBLICATIONS

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